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A sector of the EIA

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NATIONAL RADIO SYSTEMS COMMITTEE

National Association of
NAB
BROADCASTERS

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5/14/98

DAB Subcommittee

Goals & Objectives

(as adopted by the Subcommittee on May 14, 1998)

Objectives

(a) To study IBOC DAB systems and determine if they provide broadcasters and users with:

- A digital signal with significantly greater quality and durability than available from the AM and FM analog systems that presently exist in the United States;
- A digital service area that is at least equivalent to the host station's analog service area while simultaneously providing suitable protection in co-channel and adjacent channel situations;
- A smooth transition from analog to digital services.

(b) To provide broadcasters and receiver manufacturers with the information they need to make an informed decision on the future of digital audio broadcasting in the United States, and if appropriate to foster its implementation.

Goals

To meet its objectives, the Subcommittee will work towards achieving the following goals:

(a) To develop a technical record and, where applicable, draw conclusions that will be useful to the NRSC in the evaluation of IBOC systems;

(b) To provide a direct comparison between IBOC DAB and existing analog broadcasting systems, and between an IBOC signal and its host analog signal, over a wide variation of terrain and under adverse propagation conditions that could be expected to be found throughout the United States;

(c) To fully assess the impact of the IBOC DAB signal upon the existing analog broadcast signals with which they must co-exist;

(d) To develop a testing process and measurement criteria that will produce conclusive, believable and acceptable results, and be of a streamlined nature so as not to impede rapid development of this new technology;

(e) To work closely with IBOC system proponents in the development of their laboratory and field test plans, which will be used to provide the basis for the comparisons mentioned in Goals (a) and (b);

(f) To indirectly participate in the test process, by assisting in selection of (one or more) independent testing agencies, or by closely observing proponent-conducted tests, to insure that the testing as defined under Goal (e) is executed in a thorough, fair and impartial manner.

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(draft 9/27/99)

DAB SUBCOMMITTEE
IBOC DAB System Evaluation Guidelines

Addendum #1
Additional suggestion for data formatting

This addendum provides additional information regarding how proponents format data included in an IBOC system data submission to the NRSC. Proponents are asked to consider the information in this addendum as they prepare their submission.

The NRSC's Test Guideline documents request a considerable amount of information taken under numerous conditions in both the laboratory and the field. For the purpose of clarity and to promote an efficient evaluation by the NRSC, it would be helpful if as part of a submission a proponent were to summarize (when appropriate) system performance using the tabular format shown below. This information is especially valuable when provided at the "edge of coverage" or when it represents "point of failure" performance.

	Mode information					Optional		
Test	Analog/ digital	Data paths in use	TBD	FER	Avg. coder rate	MOS	S/N	Host/Intf.

where:

Test – description of test being reported;

Mode information – information provided by the proponent per Addendum 4 to the Laboratory and Field test guidelines – note that this information is proponent specific and each proponent may present different information here (three examples are shown: Analog/digital – for systems which "blend to analog;" Data paths in use – for systems with multi-level (i.e. multidescriptive) source coding schemes; and TBD – for other relevant mode information not previously disclosed;

FER – Frame error rate measured during test (*e.g.*, average FER);

Avg. coder rate – the average effective source coder rate for the test

Optional – Other useful information about the test, such as: MOS – the results of any subjective evaluations performed on the data for this test; S/N – signal to noise ratio of received RF signal; and, Host/Intf – the power ratio of the host to any interfering signals present.

EVALUATION CRITERIA DESCRIPTIONS

Audio quality – the fundamental audio quality a digital audio broadcasting system is capable of, all impairments (except those due to perceptual coding) aside. This assessment is to be made with respect to the audio quality of the existing analog broadcasting service as represented by the NRSC broadcast chain audio.

Service area – the geographical area surrounding the transmit station which can be expected to receive a listenable (usable) radio signal. Unless otherwise indicated this usually refers to the "interference-limited" service area; other service area definitions include noise-limited service area and protected contour service area. Applied separately to main channel audio and auxiliary data capacity (i.e. degree of correlation needs to be established).

Durability – characterized by a radio signal's ability to withstand interference from other radio signals (co-channel, 1st adjacent channel, and 2nd adjacent channel signals in particular) and to withstand the impairing effects of the RF channel. Applied separately to main channel audio and auxiliary data capacity (i.e. degree of correlation needs to be established).

Host analog signal impact – changes in performance of a host analog signal (main channel audio and any subcarriers) as a result of the presence of the IBOC digital signal energy associated with that host.

Non-host analog signal impact – changes in performance of the (desired) analog signal (main channel audio only) as a result of the presence of interfering IBOC signal energy (digital and analog). Interfering signals of interest include co-channel, 1st, and 2nd adjacent channel signals, individually and in combinations.

Acquisition performance – the characteristics of how a receiver "locks on" to a radio signal, including acquisition time (the elapsed time between tuning to a channel and when the audio on that channel is first heard) as a function of circumstance (for example, momentary loss of signal or channel re-tune), and audio quality immediately following acquisition. Applies to both main channel audio and auxiliary data capacity (in the latter case, performance metric is acceptable bit and/or frame error rate).

Auxiliary data capacity – characteristics of the data capacity supported by a digital radio system in excess of that needed to deliver the main channel digital audio signal, including available throughput, nature of capacity (opportunistic versus continuously available), and transmission quality and durability through the channel (bit error rate and/or other relevant digital data transmission metrics as a function of impairments).

Edge of coverage – how a digital radio system performs around its "point of failure," in particular, how abruptly the signal becomes unusable, and how the level of quality of the signal changes as the edge of coverage is approached. Note that, due to the complexities of RF signal propagation, "edge of coverage" performance may be experienced throughout a station's service area and is not restricted simply to regions near or beyond the theoretical protected contour.

Stereo separation – the amount of stereo separation present in the digital audio signal, and how it varies as a function of channel and received signal conditions.

Flexibility – represents the potential of a digital radio system to be adapted by broadcasters and manufacturers to meet the needs of listeners and consumers, both present and future. [Primarily addressed in system description portion of submission; test results not expected to provide direct evidence of system flexibility.]

Notes:

- A checkmark ("✓ ") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "DIGITAL" represent criteria evaluated using IBOC digital receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**IBOC system performance with AWGN**									
1)	Linear channel, no interferers									
2)	Linear channel, 1st-adjacent channel interference		✓	✓		✓	✓	✓		
3)	Multipath fading channel, no interferers									
4)	Multipath fading channel, 1st-adjacent channel interference									
C	**IBOC system performance with special impairments**									
1)	Impulse noise									
2)	Impulse noise, 1st-adjacent channel interference									
3)	Narrowband noise									
4)	Narrowband noise, 1st-adjacent channel interference									
5)	Airplane flutter			✓		✓	✓	✓		
6)	Airplane flutter, 1st-adjacent channel interference									
7)	Weak signal									
8)	Weak signal, 1st-adjacent channel interference		✓							
9)	Delay spread/doppler									
10)	Delay spread/doppler, 1st-adjacent channel interference									

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
D	**IBOC "digital-to-digital" compatibility performance**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference		✓	✓		✓	✓	✓		
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference									
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
7)	Simultaneous upper and lower 2nd-adjacent channel interference with non-linearity									
E	**IBOC "digital-to-digital" compatibility performance in a multipath fading channel**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference		✓	✓		✓	✓	✓		
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference									
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
7)	Simultaneous upper and lower 2nd-adjacent channel interference with non-linearity									

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
F	**IBOC "digital-to-analog" compatibility performance**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									✓
4)	Single 2nd-adjacent channel interference									
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference									
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
G	**IBOC "digital-to-analog" compatibility performance in a multipath fading channel**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									✓
4)	Single 2nd-adjacent channel interference									
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference									
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
H	**IBOC "analog-to-digital" compatibility performance**									
1)	Single 1st-adjacent channel interference									
2)	Simultaneous upper and lower 1st-adjacent channel interference		✓	✓		✓	✓	✓		
3)	Single 2nd-adjacent channel interference									

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
I	**IBOC "analog-to-digital" compatibility performance in a multipath fading channel**									
1)	Single 1st-adjacent channel interference									
2)	Simultaneous upper and lower 1st-adjacent channel interference		✓	✓		✓	✓	✓		
3)	Single 2nd-adjacent channel interference									
4)	Simultaneous upper and lower 2nd-adjacent channel interference									
J	**IBOC acquisition/re-acquisition performance**									
1)	Short interruption, linear channel									
2)	Long interruption , linear channel									
3)	Short interruption, linear channel, AWGN									
4)	Long interruption, linear channel, AWGN									
5)	Short interruption, linear channel, 1st-adj. channel interference									
6)	Long interruption, linear channel, 1st-adj. channel interference				✓					
7)	Short interruption, fading channel									
8)	Long interruption, fading channel									
9)	Short interruption, AWGN, fading channel									
10)	Long interruption, AWGN, fading channel									
11)	Short interruption, fading channel, 1st-adj. channel interference									
12)	Long interruption, fading channel, 1st-adj. channel interference									

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
K	**DAB quality**									
1)	Subjective assessment report of unimpaired IBOC audio quality (linear channel) versus analog FM	✓								
2)	"Long-form" DAT through IBOC system									
L	**IBOC "digital-to-host analog" compatibility performance**									
1)	Host analog main channel audio performance versus presence or absence of IBOC digital signal energy									
2)	Host analog main channel audio performance versus presence or absence of IBOC digital signal energy								✓	
3)	Host subcarrier audio and/or data performance versus presence or absence of IBOC digital signal energy									
4)	Host subcarrier audio and/or data performance versus presence or absence of IBOC digital signal energy									
M	**IBOC "host analog-to-digital" compatibility performance**									
1)	Digital audio, data transmission performance versus percent modulation of analog host signal			✓		✓				
2)	Digital audio, data transmission performance versus percent modulation of analog host signal									

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "DIGITAL" represent criteria evaluated using IBOC digital receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**Strong signal with low interference**									
1)	Low multipath		✓	✓		✓	✓	✓		
2)	Strong multipath									
3)	Host main channel audio compatibility								✓	
4)	Host analog 67 kHz and 92 kHz subcarrier compatibility									
C	**Single interferer**									
1)	Single 1st-adjacent channel interferer (at FCC limit)									
2)	Single 1st-adjacent channel interferer (at FCC limit) with multipath		✓	✓		✓	✓	✓		
3)	Single 1st-adjacent channel interferer (above FCC limit)									
4)	Single 1st-adjacent channel interferer (above FCC limit) with multipath									
D	**Two interferers**									
1)	Two simultaneous 1st-adjacent channel interferers (at FCC limit)									
2)	Two simultaneous 1st-adjacent channel interferers (at FCC limit) with multipath		✓	✓		✓	✓	✓		
3)	Two simultaneous 2nd-adjacent channel interferers									
4)	Two simultaneous 2nd-adjacent channel interferers (with multipath)									

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "DIGITAL" represent criteria evaluated using IBOC digital receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**IBOC system performance with AWGN**									
1)	Linear channel, no interferers		✓	✓		✓	✓	✓		
C	**IBOC system performance with special impairments**									
1)	Impulse noise			✓		✓	✓	✓		
2)	Weak signal		✓							
D	**IBOC "digital-to-digital" compatibility performance**									
1)	Co-channel interference		✓	✓		✓	✓	✓		
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference									
5)	Simultaneous upper and lower 2nd-adjacent channel interference									
6)	Single 3rd-adjacent channel interference									
F	**IBOC "digital-to-analog" compatibility performance**									
1)	Co-channel interference									✓
2)	Single 1st-adjacent channel interference									
3)	Single 2nd-adjacent channel interference									

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
H	**IBOC "analog-to-digital" compatibility performance**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference		✓	✓		✓	✓	✓		
4)	Single 2nd-adjacent channel interference									
3)	Simultaneous upper and lower 2nd-adjacent channel interference									
J	**IBOC acquisition/re-acquisition performance**									
1)	Short interruption, linear channel									
2)	Long interruption , linear channel				✓					
3)	Short interruption, linear channel, AWGN									
4)	Long interruption, linear channel, AWGN									
K	**DAB quality**									
1)	Subjective assessment report of unimpaired IBOC audio quality (linear channel) versus analog AM (and optionally, analog FM)	✓								
2)	"Long form" DAT through IBOC system									
L	**IBOC "digital-to-host analog" compatibility performance**									
1)	Host analog main channel audio performance versus presence or absence of IBOC digital signal energy								✓	
M	**IBOC "host analog-to-digital" compatibility performance**									
1)	Digital audio, data transmission performance versus percent modulation of analog host signal			✓		✓				

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "DIGITAL" represent criteria evaluated using IBOC digital receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		DIGITAL							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**System performance within protected contour and low interference (day)**									
1)	Low interference (daytime)									
2)	Performance with fading (daytime)		✓	✓		✓	✓	✓		
3)	Performance with fading (nighttime)									
4)	Host main channel audio compatibility								✓	
C	**System performance within protected contour (day and night)**									
1)	Daytime performance over entire day coverage area.									
2)	Nighttime performance over entire nighttime coverage area.									
3)	Daytime performance over entire day coverage area with fading.		✓	✓		✓	✓	✓		
4)	Nighttime performance over entire nighttime coverage area with fading.									

EVALUATION CRITERIA DESCRIPTIONS – IBOC RECEIVER RESULTS

Audio quality – the fundamental audio quality of the IBOC system, all channel impairments aside. This assessment is to be made with respect to the audio quality of the existing analog broadcasting service as represented by the NRSC broadcast chain audio.

Service area – the geographical area surrounding the transmit station which can be expected to receive a listenable (usable) radio signal. Applied separately to IBOC audio and IBOC auxiliary data capacity (i.e. degree of correlation needs to be established).

Durability – characterized by an IBOC system design's ability to withstand interference from other radio signals (co-channel, 1st adjacent channel, and 2nd adjacent channel signals in particular) and to withstand the impairing effects of the RF channel. Applied separately to IBOC audio and IBOC auxiliary data capacity (i.e. degree of correlation needs to be established).

Acquisition performance – the characteristics of how a receiver "locks on" to a radio signal, including acquisition time (the elapsed time between tuning to a channel and when the audio on that channel is first heard), and audio quality following acquisition. Applies to both IBOC audio and IBOC auxiliary data capacity (in the latter case, performance metric is acceptable bit and/or frame error rate).

Auxiliary data capacity – characteristics of the data capacity supported by an IBOC system in excess of that needed to deliver the IBOC audio signal, including available throughput, nature of capacity (opportunistic versus continuously available), and transmission quality and durability through the channel (bit error rate and/or other relevant digital data transmission metrics as a function of impairments).

Edge of coverage – how an IBOC system performs around its "point of failure," in particular, how abruptly the signal becomes unusable, and how the level of quality of the signal changes as the edge of coverage is approached. Note that, due to the complexities of RF signal propagation, "edge of coverage" performance may be experienced throughout a station's service area and is not restricted simply to regions near or beyond the theoretical protected contour.

Stereo separation – the amount of stereo separation present in the IBOC audio signal, and how it varies as a function of channel and received signal conditions.

Flexibility – represents the potential of an IBOC system to be adapted by broadcasters and manufacturers to meet the needs of listeners and consumers, both present and future. [Primarily addressed in system description portion of submission; test results not expected to provide direct evidence of system flexibility.]

EVALUATION CRITERIA DESCRIPTIONS – ANALOG RECEIVER RESULTS

Host analog signal impact – changes in performance of a host analog signal (main channel audio and any subcarriers) as a result of the presence of the IBOC digital signal energy associated with that host.

Non-host analog signal impact – changes in the performance of a (desired) analog signal (main channel audio only) as a result of the presence of interfering IBOC signals. Interfering signals of interest include co-channel, 1st, and 2nd adjacent channel signals, individually and in combinations.

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "IBOC" represent crit eria evaluated using IBOC receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**IBOC system performance with AWGN**									
1)	Linear channel, no interferers									
2)	Linear channel, 1st-adjacent channel interference		✓	✓		✓	✓	✓		
3)	Multipath fading channel, no interferers									
4)	Multipath fading channel, 1st-adjacent channel interference									
C	**IBOC system performance with special impairments**									
1)	Impulse noise									
2)	Impulse noise, 1st-adjacent channel interference									
3)	Narrowband noise									
4)	Narrowband noise, 1st-adjacent channel interference									
5)	Airplane flutter			✓		✓	✓	✓		
6)	Airplane flutter, 1st-adjacent channel interference									
7)	Weak signal									
8)	Weak signal, 1st-adjacent channel interference		✓							
9)	Delay spread/doppler									
10)	Delay spread/doppler, 1st-adjacent channel interference									

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
D	**IBOC "digital-to-digital" compatibility performance**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference									
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference		✓	✓		✓	✓	✓		
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
7)	Simultaneous upper and lower 2nd-adjacent channel interference with non-linearity									
E	**IBOC "digital-to-digital" compatibility performance in a multipath fading channel**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference									
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference		✓	✓		✓	✓	✓		
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
7)	Simultaneous upper and lower 2nd-adjacent channel interference with non-linearity									

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
F	**IBOC "digital-to-analog" compatibility performance**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference									✓
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference									
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
G	**IBOC "digital-to-analog" compatibility performance in a multipath fading channel**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference									✓
5)	Single 2nd-adjacent channel interference w/1st adj. channel interference									
6)	Simultaneous upper and lower 2nd-adjacent channel interference									
H	**IBOC "analog-to-digital" compatibility performance**									
1)	Single 1st-adjacent channel interference									
2)	Simultaneous upper and lower 1st-adjacent channel interference		✓	✓		✓	✓	✓		
3)	Single 2nd-adjacent channel interference									

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
I	**IBOC "analog-to-digital" compatibility performance in a multipath fading channel**									
1)	Single 1st-adjacent channel interference									
2)	Simultaneous upper and lower 1st-adjacent channel interference		✓	✓		✓	✓	✓		
3)	Single 2nd-adjacent channel interference									
4)	Simultaneous upper and lower 2nd-adjacent channel interference									
J	**IBOC acquisition/re-acquisition performance**									
1)	Short interruption, linear channel									
2)	Long interruption , linear channel									
3)	Short interruption, linear channel, AWGN									
4)	Long interruption, linear channel, AWGN									
5)	Short interruption, linear channel, 1st-adj. channel interference									
6)	Long interruption, linear channel, 1st-adj. channel interference				✓					
7)	Short interruption, fading channel									
8)	Long interruption, fading channel									
9)	Short interruption, AWGN, fading channel									
10)	Long interruption, AWGN, fading channel									
11)	Short interruption, fading channel, 1st-adj. channel interference									
12)	Long interruption, fading channel, 1st-adj. channel interference									

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
K	**DAB quality**									
1)	Subjective assessment report of unimpaired IBOC audio quality (linear channel) versus analog FM	✓								
2)	"Long-form" DAT through IBOC system									
L	**IBOC "digital-to-host analog" compatibility performance**									
1)	Host analog main channel audio performance versus presence or absence of IBOC digital signal energy									
2)	Host analog main channel audio performance versus presence or absence of IBOC digital signal energy								✓	
3)	Host subcarrier audio and/or data performance versus presence or absence of IBOC digital signal energy									
4)	Host subcarrier audio and/or data performance versus presence or absence of IBOC digital signal energy									
M	**IBOC "host analog-to-digital" compatibility performance**									
1)	Digital audio, data transmission performance versus percent modulation of analog host signal			✓		✓				
2)	Digital audio, data transmission performance versus percent modulation of analog host signal									

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "IBOC" represent criteria evaluated using IBOC receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**Strong signal with low interference**									
1)	Low multipath		✓	✓		✓	✓	✓		
2)	Strong multipath									
3)	Host main channel audio compatibility								✓	
4)	Host analog 67 kHz and 92 kHz subcarrier compatibility									
C	**Single interferer**									
1)	Single 1st-adjacent channel interferer (at FCC limit)									
2)	Single 1st-adjacent channel interferer (at FCC limit) with multipath		✓	✓		✓	✓	✓		
3)	Single 1st-adjacent channel interferer (above FCC limit)									
4)	Single 1st-adjacent channel interferer (above FCC limit) with multipath									
D	**Two interferers**									
1)	Two simultaneous 1st-adjacent channel interferers (at FCC limit)									
2)	Two simultaneous 1st-adjacent channel interferers (at FCC limit) with multipath		✓	✓		✓	✓	✓		
3)	Two simultaneous 2nd-adjacent channel interferers									
4)	Two simultaneous 2nd-adjacent channel interferers (with multipath)									

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "IBOC" represent criteria evaluated using IBOC receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**IBOC system performance with AWGN**									
1)	Linear channel, no interferers		✓	✓		✓	✓	✓		
C	**IBOC system performance with special impairments**									
1)	Impulse noise			✓		✓	✓	✓		
2)	Weak signal		✓							
D	**IBOC "digital-to-digital" compatibility performance**									
1)	Co-channel interference		✓	✓		✓	✓	✓		
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference									
4)	Single 2nd-adjacent channel interference									
5)	Simultaneous upper and lower 2nd-adjacent channel interference									
6)	Single 3rd-adjacent channel interference									
F	**IBOC "digital-to-analog" compatibility performance**									
1)	Co-channel interference									✓
2)	Single 1st-adjacent channel interference									
3)	Single 2nd-adjacent channel interference									

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
H	**IBOC "analog-to-digital" compatibility performance**									
1)	Co-channel interference									
2)	Single 1st-adjacent channel interference									
3)	Simultaneous upper and lower 1st-adjacent channel interference		✓	✓		✓	✓	✓		
4)	Single 2nd-adjacent channel interference									
3)	Simultaneous upper and lower 2nd-adjacent channel interference									
J	**IBOC acquisition/re-acquisition performance**									
1)	Short interruption, linear channel									
2)	Long interruption , linear channel				✓					
3)	Short interruption, linear channel, AWGN									
4)	Long interruption, linear channel, AWGN									
K	**DAB quality**									
1)	Subjective assessment report of unimpaired IBOC audio quality (linear channel) versus analog AM (and optionally, analog FM)	✓								
2)	"Long form" DAT through IBOC system									
L	**IBOC "digital-to-host analog" compatibility performance**									
1)	Host analog main channel audio performance versus presence or absence of IBOC digital signal energy								✓	
M	**IBOC "host analog-to-digital" compatibility performance**									
1)	Digital audio, data transmission performance versus percent modulation of analog host signal			✓		✓				

Notes:

- A checkmark ("✓") indicates that the results from a particular test are expected to apply to the indicated evaluation criteria.
- Test A (Calibration) provides a quality check on system testing as a whole and is not used directly for system evaluation.
- Columns marked "IBOC" represent criteria evaluated using IBOC receiver; those marked "ANALOG" represent criteria evaluated using analog (i.e. non-IBOC) receiver.

		RECEIVER UNDER TEST								
		IBOC							ANALOG	
TEST	DESCRIPTION	AUDIO QUALITY	SERVICE AREA	DURA-BILITY	ACQ. PERFORM.	AUX. DATA CAPACITY	EDGE OF COVERAGE	STEREO SEP	HOST SIGNAL IMPACT	NON-HOST SIGNAL IMPACT
B	**System performance within protected contour and low interference (day)**									
1)	Low interference (daytime)		✓	✓		✓	✓	✓		
2)	Performance with fading (daytime)									
3)	Performance with fading (nighttime)									
4)	Host main channel audio compatibility								✓	
C	**System performance within protected contour (day and night)**									
1)	Daytime performance over entire day coverage area.		✓	✓		✓	✓	✓		
2)	Nighttime performance over entire nighttime coverage area.									
3)	Daytime performance over entire day coverage area with fading.									
4)	Nighttime performance over entire nighttime coverage area with fading.									

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DAB SUBCOMMITTEE
Draft Minutes of January 8, 2000 Meeting

Chairman Smith called the meeting to order in Conference Room 7/8 of the Las Vegas Hilton, Las Vegas, NV, at 10:00AM PST. Subcommittee members and representatives present were (* indicates participation via speaker phone):

MEMBER	REPRESENTATIVE(S)	TEL NO.	E-MAIL
ABC, Inc.	Bert Goldman	972-448-3115	bert.goldman@abc.com
Adv. Television Technology Center	Charles W. Einolf	703-739-3851	ceinolf@attc.org
Bonneville International Corp.	J. Talmage Ball	801-575-7530	tball@bonnint.com
*Broadcast Signal Lab	David Maxson	508-359-8833	dmaxson@aol.com
Command Audio Corp.	Fraser Morrison	650-369-2081	fraser@sirius.com
	Thom Linden	650-631-6430	tlinden@commandaudio.com
CUE Corporation	Tim Dyson	949-862-8893	tdyson@cue.net
	Gordon Kaiser	800-858-8828	gkaiser@cue.net
Digital Radio Express, Inc.	Dwight Taylor	212-772-0795	dwightctaylor@aol.com
Emil L. Torick Corp.	Emil Torick	805-683-0811	opus16et@aol.com
Fujitsu Ten Corp. of America	Robert Tywlak	734-414-6678	rtywlak@mic.tea.fujitsu.com
Greater Media, Inc.	Milford Smith	732-247-6161	msmith@greater-media.com
International Broadcasting Bureau	Don Messer	202-619-3012	dmesser@ibb.gov
*Jefferson-Pilot Communications	Tom Giglio	404-261-2970	tgiglio@jpc.com
Journal Broadcast Group	Andy Laird	414-967-5572	laird@journalbroadcastgroup.com
Kenwood	Shoichi Suzuki	81-45-939-7009	suzukis@rdd.kenwood.co.jp
LDR, Inc.	Ben Benjamin	973-386-8860	cbenjamin@lucent.com
	David Siddall (Verner Lipfert)	202-371-6326	drsiddall@verner.com
Matsushita Electric	Robert Finger	201-348-7768	fingerr@panasonic.com
NPR	Donald Lockett	202-414-2486	dlockett@npr.org
	Mike Starling	202-414-2484	mstarling@npr.org
Sirius Satellite Radio	Robert D. Briskman	301-664-8418	rbriskman@siriusradio.com
Susquehanna Radio	Charles Morgan	717-852-2126	ctmorgan@suscom.com
USADR, Inc.	Albert Shuldiner (Vinson & Elkins)	202-639-6722	ashuldiner@velaw.com
	Glynn Walden	410-872-1526	walden@ibocradio.com
WavePhore	Mo Gardner	801-584-2800	MGardner@Wavephore.net

Guests present were:

GUEST	REPRESENTATIVE(S)	TEL NO.	E-MAIL
Becker of North America, Inc.	Horst Becker	201-327-3436	Beckerna@harman.com
Jon Grosjean Consulting	Jon Grosjean	603-525-4264	jgrosjean@ieee.org
STMicroelectronics	Jean-Jaques Raynal	831-438-7149	jean-j.raynal@st.com
Sony	Paul Feinberg	201-930-6316	paul.feinberg@am.sony.com
	Zaiwa Okanobu	+81 3 5769 5505	okanobu@shiba.sony.co.jp
Texas Instruments	Keith Gutierrez	214-480-7940	kgg@ti.com

Staff present were:

SPONSOR	REPRESENTATIVE(S)	TEL NO.	E-MAIL
CEA	Shazia Azhar	703-907-7697	sazhar@ce.org
	Ralph Justus	703-907-7638	rjustus@ce.org
	Tom Mock	703-907-7649	tmock@ce.org
	Tom Keller (consultant)	703-569-3135	N5290P@aol.com
NAB	Lynn Claudy	202-429-5340	lclaudy@nab.org
	David Layer	202-429-5339	dlayer@nab.org
	Valerie Schulte	202-429-5458	vschulte@nab.org

Member voting status for this meeting is indicated in Attachment 1 to these Minutes (also distributed at the meeting, at which time Mr. Layer reviewed the NRSC's voting status rules for the group). The agenda, and the Minutes from the 10/7/99 and 11/17/99 meetings of the Subcommittee, were approved as written.

Chairman Smith, in his opening remarks to the Subcommittee, noted the recent receipt of the USADR technical submission, as well as the expected submission by LDR on or before the 24th of January. He thanked the sponsors for their initial hard work on reviewing the USADR document, and encouraged all group members to become involved in the evaluation. He then recognized Mr. Taylor, who formally announced to the Subcommittee that DRE had entered into a partnership with USADR [Attachment 2 not distributed at the meeting, contains additional information regarding this].

Agenda Items :

Item 5 – Report from Test Guidelines Working Group (TGWG)

Mr. Laird, TGWG Chairman, stated that his group had not met since the last DAB Subcommittee meeting, and also that Mr. Layer was in the process of preparing addendums to the Laboratory Test Guidelines describing the AM and FM NRSC Reference Chain recordings. He expects these new addendums to be ready for consideration by this group at its next meeting.

Item 6 – Report from Evaluation Working Group (EWG)

Dr. Messer, EWG Chairman, began his report by reviewing briefly the process the EWG is currently undertaking, namely, the review of IBOC submissions to determine if IBOC is significantly better than existing analog services. He noted that the USADR submission, received on 12/15/99, consisted of written, audio, and video materials, and that the EWG was presently preparing a list of questions for USADR based on preliminary review of this material.

The next meeting of the EWG will be a telcon on 1/14/00, followed shortly thereafter by a face-to-face meeting at NAB headquarters on 2/1/00. Mr. Layer mentioned that the entire text of the USADR submission is available on the NRSC website.

Mr. Benjamin then expressed LDR's intention to offer a submission to the NRSC on 1/24/00 (the FCC's comment deadline in the terrestrial DAB NPRM), indicating that it was a "complete" submission and would include test data on both AM and FM IBOC systems. Chairman Smith suggested that, in the interest of fairness, USADR be allowed to supplement

their 12/15/99 submission to the NRSC within a 2-week "window" commencing on the LDR submission date. After some discussion the group agreed to this proposal without dissent.

Item 7 – Follow-on evaluation efforts

Chairman Smith asked for comments from the group on possible follow-on evaluation efforts, and Mr. Layer agreed to outline for the group how one possible approach, that of IBOC system standards development, could proceed. The standards development process would begin with the NRSC drafting and releasing a request for proposal (RFP) describing the requirements a candidate system would need to satisfy for consideration, noting that one of these requirements would most likely be a "phase-1-like" showing of system performance (that is, a submission commensurate with the NRSC's Lab and Field Test Guidelines). Such an RFP would have a fixed response time, for example, 60 days.

Once the filing window for the RFP expired, the NRSC would direct the testing of candidate systems through an independently conducted test program, using procedures developed by the NRSC (these procedures would probably be similar to those included in the test guidelines documents). This testing would be necessary even if only one system was submitted for possible standardization; in such a case, the purpose of the tests would be to verify the performance claims of the proponent as well as to collect any additional information deemed necessary by the NRSC. In the situation where more than one system is submitted, another goal of this testing would be to determine, for each operating parameter, which system exhibited the best performance. Ultimately, this process would result in a final report commenting on the results of the test program and making recommendations for possible IBOC system standardization.

There were a number of comments made regarding this scenario. Chairman Smith noted that such an endeavor was challenging and expensive, with a significant amount of work falling to the sponsoring organizations. Mr. Justus endorsed the outlined approach whole-heartedly, stating that CEA members were in favor of having a single system standard for IBOC DAB, and adding that the NRSC should do this as soon as it's appropriate. Mr. Morgan pointed out that the FCC is likely to rely upon industry groups (such as the NRSC) to undertake this kind of standardization effort, and indicated his desire to make the NRSC's intentions in this regard formal assuming that the DAB Subcommittee's current goals are satisfied.

To that end, Mr. Morgan made a **motion** that the NRSC should formally state its intention to proceed to a standards setting effort if and only if the DAB Subcommittee determines that it current goals are satisfied. [The primary goal of the Subcommittee is to determine if IBOC DAB systems offer significantly improved performance over existing analog systems.] Dr. Messer **seconded** this motion, after which Chairman Smith asked for discussion. Mr. Shuldiner indicated that USADR could not presently support this motion, since the Subcommittee doesn't have enough information yet to see if a standards setting effort is warranted. He recommended that the Subcommittee wait until all (currently expected) proponent submissions have been received and evaluated. Mr. Claudy also felt that this motion was premature and suggested that the NRSC not act on it until after the 1/24/00 comment deadline, noting that it is not yet clear if 0, 1, or 2 systems might qualify for such an effort.

A number of group members endorsed the proposal, including Messrs. Justus and Benjamin, and Dr. Messer. Mr. Siddall suggested that whether there is 1 or more system is irrelevant, and pointed out that in the Commission's DTV proceeding a rigorous, independent,

industry-sponsored standards setting was undertaken with only one system. He, and others, felt this process should begin as soon as possible. Mr. Kaiser noted that adoption of this motion would make it clear to the FCC that the NRSC is prepared to assume a standards setting role. As a point of clarification, Mr. Justus suggested that the phrase "standards setting effort" in the motion be interpreted as described earlier in the meeting by Mr. Layer. [See the first two paragraphs under this item.]

The discussion was concluded and a roll-call vote of members with voting status present was taken. With the only negative vote cast by USADR, the motion **passed**. Mr. Justus suggested that the NRSC make the Commission aware of its intentions, to which Mr. Claudy responded the appropriate action would be to submit these Minutes into the record of the terrestrial DAB proceeding.

Item 8 – Other business

Mr. Justus reminded the group of CEA's receiver test and measurement workshop, being held from 1/27/00 to 1/29/00 in Monterey, CA, and invited any interested members to contact him for additional information. Also, Mr. Walden offered a ride in the USADR demo van to any interested group members at the conclusion of the meeting.

Item 9 – Next meeting

The next meeting of the DAB Subcommittee was scheduled for Friday, March 24, 2000, to be held in Washington, D.C. at NAB headquarters (exact time to be announced). Also, the meeting following that was announced, to be held on Saturday, April 8th, to be held in Las Vegas, NV, in conjunction with NAB's annual convention (exact time and place to be announced).

Chairman Smith adjourned the meeting at 11:30AM PST.

Respectfully Submitted,

David H. Layer
Senior Engineer
Science & Technology Department
National Association of Broadcasters

DISTRIBUTED ON JANUARY 24, 2000

(ATTACHMENT 1)

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DHL 1/5/00 8:37 AM

VOTING STATUS – DAB SUBCOMMITTEE
(for January 8, 2000 Subcommittee meeting)

Members with voting status

Adv. Television Technology Center
Broadcast Signal Lab
CD Radio, Inc.
Command Audio Corp.
Digital Radio Express, Inc.
Emil L. Torick Corp.
Fujitsu Ten Corp. of America
Greater Media, Inc.
International Broadcasting Bureau
Jefferson-Pilot Communications
Journal Broadcast Group
Kenwood Americas Corp.
LDR, Inc.
Mitretek Systems
NPR
Schaffnit Consulting
Susquehanna Radio Corp.
USADR, Inc.

Members needing TWO consecutive attendances to reestablish voting status

ABC, Inc.
Alpine Electronics of America, Inc.
Bonneville International Corp.
Canadian Assoc. of Broadcasters
Clariti Telecommunications
Communications Research Centre
Cutting Edge
FCC
Hammett & Edison, Inc.
John F.X. Browne & Associates
Modulation Sciences, Inc.
MTN Engineering Inc.
Orban Inc.
Richard W. Burden Associates
Satellink Communications, Inc.
Subcarrier Systems Corp.
Terion, Inc.
Timothy L. Warner, Inc.
Visteon Automotive Systems
WavePhore

(Attachment 2)

PRESS RELEASE

DIGITAL RADIO EXPRESS

For Immediate Release

Contact:	David Salemi	Diane Murphy	Dwight Taylor
December 14, 1999	Director of Marketing		Managing Director
	USA Digital Radio	Federal City Communications	Digital Radio Express
	410-872-1533	202-662-1280	212-772-0795
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IBOC DAB TECHNOLOGY DEVELOPERS CONSOLIDATE EFFORTS

- Digital Radio Express Joins Forces with USA Digital Radio -

COLUMBIA, MD, and MILPITAS, CA (December 14, 1999) -- USA Digital Radio, Inc. (USADR), and Digital Radio Express (DRE), both privately-held technology companies, today announced a strategic alliance that will unify efforts and expedite the rollout of In-Band On-Channel Digital Audio Broadcasting (IBOC DAB). Under an agreement between the two IBOC DAB proponents, DRE will support efforts to commercialize USADR's IBOC DAB system. The companies will cooperate in the development of USADR's IBOC DAB technology and the regulatory process required for its adoption in the United States. DRE will focus its business on data ventures, including specialized data applications for USADR's system.

"This is a win-win venture for USADR, for DRE, for the broadcast and audio industries, and for the consumer" said Robert J. Struble, president and chief executive officer, USA Digital Radio, Inc. "Welcoming DRE into our growing coalition strengthens the unified effort to achieve our goal of moving IBOC DAB forward under one technical standard. Further, DRE's concentrated efforts to develop data applications for digital radio will greatly increase the value of IBOC DAB to broadcasters, manufacturers and consumers."

"To expedite the commercialization of IBOC DAB, it made sense for us to join forces with USA Digital Radio," said Dwight Taylor, Managing Director, Digital Radio Express. "We evaluated several options available to us. Becoming part of USADR's coalition was the obvious and best choice, in light of the superiority of their technological achievements, business plan and the strides they have made on the regulatory front. We plan to play an

active role in implementing digital radio and capitalizing on the unlimited potential that data applications offer."

Digital Audio Broadcasting is a digital method of transmitting virtual CD quality audio signals to radio receivers. IBOC DAB is a broadcasting technology that uses the current radio spectrum to transmit existing AM and FM analog simultaneously with new high-quality digital signals. This technology provides a unique opportunity for broadcasters and listeners to convert from analog to digital radio without service disruption while maintaining current dial positions of existing stations. Listeners who purchase digital radios would receive their favorite radio stations with superior sound quality free from static, hiss and noise, and with reduced interference.

About Digital Radio Express
Digital Radio Express is developing technology in the field of wireless mobile data transmission and reception. Currently, DRE is using its intellectual property to implement new, more efficient utilization of radio subcarriers for the delivery of mobile data. In partnership with CUE Corp., a data services company, and ST Microelectronics, a semiconductor manufacturer, DRE has created a design which permits exponentially higher net data throughput, at low cost, for such products as internet appliances, car radios and a variety of mobile data communication devices.

About USA Digital Radio, Inc.
USA Digital Radio is developing and marketing In-Band On-Channel Digital Audio Broadcasting (IBOC DAB) technology for AM and FM radio. The Federal Communications Commission (FCC) recently took a key step in the regulatory approval process of IBOC DAB by issuing a *Notice for Proposed Rulemaking* on November 1, 1999. USA Digital Radio led the approval process with its filing of a *Petition for Rulemaking* with the FCC on October 7, 1998.

Owners of USA Digital Radio include: ABC, Inc., New York, New York (NYSE:DIS); AMFM, Inc., formerly Chancellor Media Corporation, Dallas, Texas (NYSE:AFM); CBS Corporation, New York, New York (NYSE:CBS); Chase Capital Partners, New York, New York, an affiliate of Chase Manhattan Corporation (NYSE:CMB); Citadel Communications Corporation, Las Vegas, Nevada (NASDAQ:CITC); Clear Channel Communications, San Antonio, Texas (NYSE:CCU); Cox Radio, Inc., Atlanta, Georgia (NYSE:CXR); Cumulus Media, Inc., Milwaukee, Wisconsin (NASDAQ:CMLS); Emmis Communications, Indianapolis, Indiana (NASDAQ:EMMS); Entercom Communications Corporation, Bala Cynwyd, Pennsylvania (NYSE:ETM); Gannett Company, Inc., Arlington, Virginia (NYSE:GCI); Hispanic Broadcasting Corporation, Dallas, Texas (NASDAQ:HBCCA); Radio One, Inc., Lanham, Maryland (NASDAQ:ROIA); and Sinclair Broadcast Group, Inc., Baltimore, Maryland (NASDAQ:SBGI).

USA Digital Radio's efforts include development agreements with several outside parties including Xetron Corporation, Cincinnati, Ohio; Fraunhofer Institut fur Integriete Schaltungen (IIS), Erlangen, Germany; BittWare Research Systems, Concord, New Hampshire; Nautel Limited, Nova Scotia, Canada; QEI Corporation, Williamstown, New Jersey; Broadcast Electronics, Quincy, Illinois; Kenwood Corporation, Tokyo, Japan; Texas Instruments, Dallas, Texas; Continental Electronics Corporation, Dallas, Texas; Andrew

Passive Power, Gray, Maine; Energy-Onix, Valatie, New York; Orban, San Leandro, California; Shively Labs, Bridgton, Maine; and Telos Systems/Cutting Edge, Cleveland, Ohio.